There is always some possibility of some of the nozzles becoming choked with dirt, fibrous matter, small leaves, weeds, &c., especially when the water is taken from a river. It is therefore the usual practice to increase the number of nozzles to allow for this, and to throttle the water-supply somewhat at the injection valve for normal working. Similar provision may also be necessary for overloads on the engine according to circumstances.

If for any reason the vacuum in the condenser should fall off, as might occur, for instance, if the air-pump became defective, this would correspondingly affect the head of water available for injection, and if the injection valve could not be opened further, the amount of water injected would also fall off and the vacuum thereby would be further reduced. Thus there will be some critical vacuum below which the amount of water available is not sufficient to condense the steam, and the vacuum would then fall rapidly towards zero. Calculations indicate that this critical vacuum is not far from the vacuum corresponding to the suction lift under ordinary conditions of operation, and this illustrates one of the dangers of having an excessive suction lift.

When the air-pump is driven directly from the engine, and there are no auxiliary means of creating a vacuum in the condenser, the condenser pressure will usually be atmospheric on starting the engine. The air-pump is depended upon to build up the vacuum to the point at which water begins to be injected, the steam exhausted during this period of no-load running being condensed by the relatively cold metal and water present in the condenser. It is therefore necessary to have an efficient air-pump of large capacity, and to keep down the designed volume of the jet condenser to a safe value, or the vacuum required to lift the injection water may never be reached, and the condenser therefore fails to get water. In such cases the condenser volume is usually made about one-half that of the low-pressure cylinder, and the volumetric displacement of the air-pump per stroke about one-third the volume of the condenser.

With independently-driven air-pumps, however, the pumps are started

before the engine or turbine, and therefore this arrangement has greater stability of operation than that of direct-driven air-pumps.

Surface Condensers.—When suitable feed water is not available for the boilers, or is too costly to use for this purpose, it is usual to install surface condensers. The surface condenser most commonly used consists of a closed vessel of suitable shape containing tubes, usually of brass, on which the steam condenses. The cooling or circulating water is circulated through the tubes and absorbs the heat from the steam; thus the water of condensation is kept separate from the circulating water, and is therefore available for feeding again to the boilers.

One arrangement of a counter-current surface condenser * (Westinghouse) is shown in fig. 6. The tubes are supported in the two tube plates in a manner similar to that shown in fig. n, p. 228, and are packed so as to prevent leakage of circulating water to the steam side of the tubes. The circulating

* *Proceedings of the Institution of Mechanical Engineers,* January-February, 1913.